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Re: German Patent No. 199 62 845.9-33

"Process to examine an object"

I, Elise Duvekot, hereby certify that I am fully familiar with the German and English languages and that I am capable of translating from German into English. To the best of my knowledge and belief, the foregoing is an accurate and complete translation of the copy before me in the German language. In witness whereof I sign,

Elise Duvekot April 19, 2001
(Elise Duvekot, Translator)

Öffentlich bestellte und beeidigte Urkundenübersetzerin und Dolmetscherin der englischen Sprache für Baden-Württemberg
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TRANSLATION

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Process to examine an object

Description

The invention relates to a process to examine at least one object, whereby properties of the object are detected by various measurements within a spatial-frequency space formed by spatial frequencies.

Preferably, the various measurements take place at different times.

Examinations of the spatial-frequency space are employed in a wide array of technical fields. Since pulse spaces correspond to spatial-frequency spaces, the term spatial-frequency space also encompasses pulse spaces. The designation spatial-frequency space serves to clarify the fact that the invention also relates to a process in which no pulse transmission occurs.

A known problem encountered when imaging spatial-frequency spaces is that a very long measuring time is needed when a high local resolution is combined with a high spatial-frequency resolution.

A keyhole process for solving this problem is known. In this process, a high-resolution image involving the detection of the entire spatial-frequency space is determined at least at one point in time. In one or more measuring steps, a central area of the spatial-frequency space is imaged that determines the contrast of the reconstructed image. Subsequently, the high-resolution image is mathematically linked to the recorded image(s) of the central areas of the spatial-frequency space in such a way that a high-resolution image having a contrast that corresponds to the point in time of the recording is determined for the other time or times.

This known process has the disadvantage that contrast changes between consecutive measurements can only be determined if they have a sufficiently large spatial extension.

This disadvantage is particularly detrimental when functional parameters are being detected.

Thus, for instance, in functional magnetic resonance imaging, there is a need for parameters that influence nuclear magnetic resonance signals to be detected with the highest possible spatial resolution.

The invention is based on the objective of creating a process with which it is possible to detect a change in parameters when the spatial areas affected by the change are relatively small.

This objective is achieved according to the invention in that various measurements take place in at least one shared area of the spatial-frequency space and, additionally, in areas of the spatial-frequency space that are different from each other.

Preferably, the measurements detect the spatial-frequency space in images taken at different times.

In particular, the invention provides for examining areas of the spatial-frequency space at rates of occurrence that differ from each other, whereby preferably there are at least three different rates of occurrence for detecting areas.

It is advantageous for the measurements of the areas to take place with at least three different detection rates of occurrence.

Preferably, at least one, for instance, centrally located area of the spatial-frequency space is detected in several measurements while other areas are not detected at all or else only detected in a single measuring procedure.

It is advantageous to carry out the process in such a way that the overlapping areas cover a central region of the spatial-frequency space.

An advantageous embodiment of the process is characterized in that the additional, preferably not central, areas in the spatial-frequency space are at a distance from each other that is greater than their spatial-frequent extension in the direction of this distance.

It is advantageous to carry out the process in such a way that the other areas of the spatial-frequency space extend, at least partially, parallel to each other.

Here, it is especially advantageous for the disjunctive elements of the individual sets to extend, at least partially, parallel to each other in the spatial-frequency space.

An advantageous embodiment of the process is characterized in that the measurements are carried out in such a way that a cycle is formed in which at least some of the areas of the spatial-frequency space that differ from each other are once again detected in additional measurements.

An advantageous embodiment to carry out the process is characterized in that the areas detected form a disjunctive set in at least one measurement.

Additional advantages, special features and practical improvements of the invention ensue from the subordinate claims and from the following presentation of a preferred embodiment of the invention with reference to the drawing.

The drawing shows a schematic depiction of a detection of a spatial-frequency space with several consecutive measurements.

The image shows the detection of a spatial-frequency space with N $\times$ N points as an example.

For purposes of simplifying the graphic representation, a two-dimensional depiction was chosen, although the invention is by no means restricted to the detection of two-dimensional spatial-frequency spaces, but rather, it is suitable to detect spatial-frequency spaces having any desired number of dimensions.

A first measuring procedure detects a central area **1** as well as areas **10** of the spatial-frequency space that are at a distance from the central area **1** – represented here in the form of broken lines – and that are preferably essentially parallel to the spatial-frequency space.

In a subsequent measuring procedure, the central area is detected once again. In addition, other areas **20** – represented by the dash-dot lines – of the spatial-frequency space that lie outside of the central area **1** are also detected. The other areas **20** of the spatial-frequency space preferably extend parallel to each other and anti-parallel to the other areas **10** detected in the preceding measuring step.

Subsequently, the measuring procedure is repeated. In this repetition, the central area **1** as well as other areas **30** – indicated by the dash-dot-dot lines – of the spatial-frequency space are detected.

By means of a merely selective detection of the high-frequency data, the time advantage of a keyhole method is essentially maintained. Moreover, noise effects are suppressed.

Furthermore, the images shown have a high spatial resolution corresponding to the overall images of the spatial-frequency space.

It is particularly advantageous to image a suitable SPARCE sequence.

Preferably, an imaging pattern corresponds to a SPARCE sequence having the following formula:

SPARCE (f,n) = [N/2-n, N/2-f-n, N/2-2f-n,...(KEYHOLE)...-N/2+3f-n, -N/2+2f-n, -N/2+f-n]

In an advantageous manner, the entire spatial-frequency space is imaged, whereby the spatial-frequency space can be considered, for example, to be an $N \times N$ image matrix. The image matrix has a slight covering of high spatial frequencies as well as a more thoroughly covered, so-called keyhole area.

A SPARCE sequence, SPARCE <f,n>, contains indices f,n, wherein f stands for an image factor and n for a running time variable, whereby it applies that $(0 \leq n < f)$.

By means of a relatively small or infrequent detection of areas having high spatial frequencies, a time advantage is achieved, in addition to which the correlation between high-frequency noises is reduced, which is something particularly advantageous.

Another improvement can be achieved with an even-numbered sampling factor f in that even and odd echoes are detected separately.